

Analysis of the Cape Breton Snow Crab Fishery, 1979

by

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ABSTRACT

During 1977, 1978 and 1979 in-port and at-sea sampling of catches was carried out for the six Cape Breton snow crab fishing areas (Fig. 1). Tagging studies were performed in northwestern, northeastern and southeastern Cape Breton. Data from these studies, together with data derived from fishermen's log books has been analyzed to provide a biological assessment of the Cape Breton snow crab fishery.

Area 11 (middle-eastern Cape Breton). The snow crab fishery in Area 11 began in 1977, although no data are available prior to 1979. In 1979 there were 11 licensed inshore boats and five boats with offshore permits in this area. Landings in 1979 were 507 MT, from an estimated total commercial stock on the fished grounds of 790 MT; this represents an exploitation rate of 64%. No information on moulting, growth and recruitment are available for this stock.

Area 13 (south Cape Breton). The snow crab fishery in Area 13 began in 1979 with permits being issued to eight boats. Landings in 1979 were 27 MT and the exploitation rate on the grounds fished was estimated at 39%. There is no information on moulting, recruitment and growth for this stock. It is not known to what extent the total commercial stock in this area was fished.

Area 12 (southwestern Cape Breton). Area 12 was first opened to 14 inshore permit holders in 1979. The fishing grounds are in comparatively shallow water, and the stock appears to contain a large proportion of sublegal sized male crabs. A significant pulse of recruitment and growth, estimated at 114% of the initial commercial biomass, occurred during the first 5 wk of the 1979 fishing season (July-early August). The 1979 catch was 213 MT giving an exploitation rate of 50% of the estimated commercial biomass on the grounds fished. It is not known to what extent the total commercial stock in area 12 was fished.

Area 8 (northwestern Cape Breton). Area 8 was first exploited in the late 1960's, and is currently the most productive of the Cape Breton snow crab areas. Effort has increased from eight boats in 1977 to 14 boats in 1978 and 27 licensed boats in 1979. After landings of 516 MT in 1977 and 1941 MT in 1978, a TAC of 1406 MT was set for 1979. During 1978 the exploitation rate was estimated at 65%, and 1075 MT was calculated to remain on the grounds at the end of the 1978 fishing season. The exploitation rate during 1979 was estimated at between 55 and 62%, and 846 MT was calculated to remain at the end of the fishing season. Additions of commercial biomass, from growth and recruitment, estimated at 1189 MT and 790 MT, occurred during the initial weeks of the 1978 and 1979 fishing seasons respectively. There are indications that between season growth and recruitment may also occur. Estimates indicate a decline in total commercial stock from 3016 MT in 1978 to 2239 MT in 1979.

Area 10 (northeastern Cape Breton). The fishery in Area 10 started in 1976. Forty-eight boats were licensed to fish this area in 1979, compared to 36 in 1978 and 25 in 1977. However, landings have decreased from 331 MT in 1978 to 289 MT in 1979. The rate of exploitation in 1979 was estimated at between 62 and 71% of the total commercial stock fished (calculated to be between 378 and 426 MT). A biomass addition, through moulting, estimated at 101 MT (31% of the available biomass at the start of the 1979 fishing season) occurred during the fishing season. It is not known to what extent the total commercial stock in this area was fished in 1979.

Area 9 (southeastern Cape Breton). The snow crab fishery in Area 9 began in 1977. Landings have increased, with effort, from 490 MT in 1978 to 682 MT in 1979. Fifteen licensed inshore boats, with the possible addition of 10 boats with offshore permits, fished Area 9 in 1979. The 1979 landings were 682 MT, from an estimated commercial stock on the grounds fished of between 1069 and 1185 MT. The exploitation rate in 1979 is estimated at between 58 and 65%. No information on moulting, recruitment and growth are available for Area 9. It is not known to what extent total commercial stock in this area was fished.

Résumé

En 1977, 1978 et 1979, les prises de crabe des neiges provenant des six zones de pêche du Cap-Breton (Fig. 1) ont été échantillonnées, tant au port qu'en mer. On a étiqueté des crabes dans le nord-ouest, le nord-est et le sud-est de l'île. Les données découlant de ces études, ainsi que celles extraites des journaux de bord des pêcheurs ont été analysées et ont servi à une évaluation biologique de la pêcherie de crabe des neiges du Cap-Breton.

Zone 11 (centre-est du Cap-Breton). La pêche du crabe des neiges dans la zone 11 débuta en 1977, bien qu'on n'ait pas de données antérieures à 1979. Cette année-là, il y avait, dans cette zone, 11 bateaux côtiers autorisés à pratiquer cette pêche et cinq munis de permis de pêche au large. Les débarquements ont été de 507 t en 1979, à même un stock commercial total sur les lieux de pêche estimé à 790 t; ceci représente un taux d'exploitation de 64%. Nous n'avons pas de données sur la mue, la croissance de le recrutement de ce stock.

Zone 13 (sud du Cap-Breton). La pêche du crabe des neiges dans la zone 13 débuta en 1979, avec la délivrance de permis à huit bateaux. Les débarquements en 1979 ont été de 27 t, et le taux d'exploitation sur les lieux pêchés estimé à 39%. On ne possède pas de données sur la mue, le recrutement et la croissance de ce stock. On ignore à quel degré le stock commercial total est exploité dans cette zone.

Zone 12 (sud-ouest de Cap-Breton). La zone 12 a été ouverte à la pêche pour la première fois en 1979, avec 12 détenteurs de permis côtiers. Les bancs de pêche sont situés dans des eaux relativement peu profondes, et le stock semble contenir une forte proportion de mâles de taille sublégal. Il se produisit, dans les 5 premières semaines de la saison de pêche 1979 (juillet-début août), une forte poussée de recrutement et de croissance, estimée à 114% de la biomasse commerciale initiale. Les prises de 1979 furent de 213 t, soit un taux d'exploitation de 50% de la biomasse commerciale estimée sur les lieux de pêche. On ignore à quel degré le stock commercial total a été exploité dans la zone 12.

Zone 3 (nord-ouest du Cap-Breton). La zone 3 commença à être exploitée vers la fin des années 1960. Elle est présentement la région du Cap-Breton la plus productive en crabe des neiges. L'effort a passé de huit bateaux en 1977 à 14 en 1978 et à 27 bateaux autorisés en 1979. Après des débarquements de 516 t en 1977 et de 1 941 t en 1978, on a établi un TPA de 1 406 t pour 1979. En 1978, le taux d'exploitation a été estimé à 65%, et l'on a calculé que 1 075 t étaient encore sur les lieux de pêche à la fin de la saison 1978. Le taux d'exploitation de 1979 a été estimé à 55-62%, et l'on calcule que 846 t étaient encore sur les lieux de pêche à la fin de la saison de pêche. Les additions, estimées à 1 189 t et 790 t, à la biomasse commerciale, par croissance et recrutement, se produisirent dans les premières semaines des saisons de pêche 1978 et 1979 respectivement. On a des indications qu'il peut y avoir également croissance et recrutement entre les saisons. Les estimations indiquent un déclin du stock commercial total, soit de

3 016 t en 1978 à 2 239 t en 1979.

Zone 10 (nord-est du Cap-Breton). La pêche dans la zone 10 commença en 1976. Quarante-huit bateaux étaient autorisés à pratiquer la pêche dans cette zone en 1979, comparativement à 36 en 1978 et 25 en 1977. Cependant, les débarquements ont décliné, passant de 331 t en 1978 à 239 t en 1979. Le taux d'exploitation en 1979 a été estimé à 62-71% du stock commercial total exploité (compris, d'après les calculs, entre 378 et 426 t). Une addition à la biomasse, par mue, estimée à 101 t (31% de la biomasse disponible au début de la saison de pêche 1979) se produisit pendant la saison de pêche. On ignore à quel degré le stock commercial total de cette zone a été exploité en 1979.

Zone 9 (sud-est du Cap-Breton). La pêche du crabe des neiges dans la zone 9 débuta en 1977. Les débarquements ont augmenté en même temps que l'effort, passant de 490 t en 1978 à 682 t en 1979. Quinze bateaux côtiers autorisés, avec l'addition possible de 10 bateaux possédant des permis de pêche au large, ont pêché dans la zone 9 en 1979. Les débarquements cette année-là furent de 682 t, à même un stock commercial sur les lieux de pêche estimé à 1 069-1 185 t. Le taux d'exploitation en 1979 a été estimé à 58-65%. Nous n'avons pas de données sur la mue, le recrutement et la croissance dans la zone 9. On ignore à quel degré le stock commercial total de cette zone a été exploité.

INTRODUCTION

Since its inception in 1972 the Cape Breton-based fishery for snow crab, Chionoecetes opilio, has expanded considerably. Presently, the fishery encompasses almost the whole circumference of Cape Breton. Cape Breton snow crab landings and fishing effort (in terms of the number of participating boats) has risen steadily over the past few years [Table 1].

Boats used to fish snow crabs around Cape Breton are generally 30-45 feet (9-14 m) in length and of the "Cape Islander" type. Traps are inspected daily, when possible, and are set on mud bottoms at depths ranging from 26-140 fathoms (47-252 m) [Fig. 1]. The most commonly used snow crab traps are 5x5x1.6 feet (1.5x1.5x0.5 m) metal frames covered with 3-4 inch (7-10 cm) mesh, with 2 fishing heads. However, wooden and Japanese-type conical crab traps predominate in northeastern Cape Breton. The regulations limiting the maximum number of traps per boat to 30 for licensed fishermen and 20 for permit fishermen is generally well adhered to. The Cape Breton fishing season for snow crabs currently extends from the beginning of July to the end of September, although the exact dates may vary between specific areas.

The fishery is confined to male crabs over 95 mm carapace width. The minimum size limit is well above the 80-mm carapace width size of 100% maturity for males (Watson 1970a). Female snow crabs are effectively excluded from the fishery as they undergo a terminal moult to maturity below the legal size limit. The fact that practically all mature females caught from around Cape Breton are berried indicates that a high reproductive potential is being maintained in the stocks. For biological assessment purposes the Cape Breton snow crab fishery has been divided into 6 areas [Fig. 1]. Two of these areas, 12 and 13, were first opened to Cape Breton snow crab boats in 1979. In addition, 27 permits were granted in 1979 for fishing in offshore areas of eastern Cape Breton (outside the boundaries defined in Fig. 1). However, some of these offshore permit holders may have fished in inshore areas 9 and 11. Table 1 shows the 1979 landings for the various Cape Breton snow crab fishing areas. Snow crab catches from the northwestern Cape Breton stock (area 8) made up 43% of the overall 1979 Cape Breton catch of 3,225 MT (Area Managers Statistics). As a stock conservation measure a quota of 1,406 MT was set in 1979 for area 8, based partly on a biological assessment by Bailey (1978b).

During 1977, 1978 and 1979 in-port and at-sea sampling of snow crab catches has been carried out around Cape Breton. Tagging studies have also been performed in Areas 8, 9 and 10. Data from these studies, together with data derived from fishermen's log books, are analyzed in this paper to provide an assessment of the Cape Breton snow crab stocks for management consideration.

MATERIALS AND METHODS

Cape Breton snow crab fishermen are required to maintain log books giving details of daily catch weight, effort (in terms of number of trap hauls), trap location and soak time. Data from log books, together with information gathered by in-port and at-sea sampling of snow crab catches, during the 1977-'79 fishing seasons on shell hardness and catch size frequencies, have been used to assess the biomass, population size structure and exploitation rate of commercially sized snow crabs in each of the 6 Cape Breton fishery areas. Data derived from tagging studies in 1978 and 1979 have enabled additional stock assessments in 3 areas (3, 9 and 10).

In 1978, tagging was done from commercial boats at the start of the fishing season in area 8, northwestern Cape Breton (see Bailey, 1978b for details). Although the vinyl body tag used is lost at moulting, tagged animals from the 1978 study were still being recovered during the 1979 fishing season. Similar tagging studies, using the vinyl body tag, were undertaken in southeastern Cape Breton (area 9) and northeastern Cape Breton (area 10) in 1979.

Leslie analysis was used to estimate stock size on the fishing grounds from logbook-derived CPUE data. However, it is acknowledged that Leslie estimates can be biased by the following:

- 1) Catchability is low during premoult, high during postmoult and intermediate during intermoult. Catchability is also affected by temperature (McLeese and Wilder 1958); however, at the depths at which snow crabs are trapped, bottom temperature can be expected to remain fairly constant (catchability should ideally remain constant throughout the fishing season for application of Leslie analysis).

- 2) There is pulse recruitment (with moulting) during the fishing season that varies in intensity and date from year to year and place to place.

- 3) Quality of effort is probably not constant: fishermen are more mobile than the crabs and can move from areas of low CPUE to higher CPUE, but require an increasing CPUE with increasing distance from port. Quality of effort also changes with soak time and as fishermen become more experienced (see Ricker (1975) for detailed account of sources of discrepancy).

RESULTS

Area 11 (middle eastern Cape Breton)

The snow crab fishery in area 11 probably began in 1977; although we have no fishing effort, or catch size frequency data prior to 1979.

Port and at-sea sampling:

During the 1979 fishing season catch size-frequency histograms for male crabs were obtained from port sampling in July and August and from at-sea sampling on commercial boats in August [Fig. 2]. The unimodal shape of the histograms precludes separation of the data into normal components for moult increment studies. Histograms from in-port sampling are deficient in the smaller crab sizes, compared to the at-sea samples, due to the fishermen culling the catch of sub-legal sized crabs. Mean crab carapace width, from in-port sampling data, increased from 103.4 mm in July to 106.0 mm in August. Data on shell hardness throughout the fishing season for this area was too unreliable to be considered.

Log books:

Analysis of log books from the 11 licensed crab boats in area 11, [Table 2] together with log books from 5 boats with offshore permits that possibly fished in the inshore area, enabled CPUE (kg.trap haul⁻¹) to be plotted against cumulative catch, for regular intervals through the 1979 fishing season [Fig. 3], so that a Leslie estimate of initial biomass (B_0) could be made. The slope of the linear regression gives a value for catchability (q), for the rectangular traps, of 9.573×10^{-5} . Figure 3 shows a sudden unexplained rise in CPUE during the final week of the fishing season that has been ignored in the Leslie analysis. Assuming catchability (q) was constant, and that there was no recruitment or growth serving to increase the commercial stock or migration or natural mortality acting to decrease the stock, throughout the fishing season, we can estimate the initial biomass (B_0) of commercial size crabs available at the start of the fishing season (found by the intercept of the linear regression on the x-axis) as 790 MT (95% confidence limits: 713 and 891 MT). The total commercial catch (Y) from area 11 during the 1979 fishing season was 507 MT. Therefore, 64.2% (95% confidence limits: 70.6% and 56.9%) of the initial, available biomass appears to have been caught during the 1979 fishing season, leaving 283 MT on the fishing grounds at the season's close. Corresponding values for instantaneous rate of fishing mortality (F) are 1.03 and 1.22-084*.

Area 13 (south Cape Breton)

The commercial fishery for snow crab in south Cape Breton, area 13, began in 1979 with inshore permits being issued to 8 boats. Bailey (1978a) presents size frequency histograms for trap caught male snow crabs from the Chedabucto Bay (area 13) virgin stock in 1976.

Port and at-sea sampling:

No catch size-frequency data was collected from area 13 during the 1979 fishing season.

*F values derived from logbook data, for all areas, should be considered overestimates, since natural mortality has not been taken into account and a type 1 fishery (Ricker, 1975) has been assumed (i.e. natural mortality occurs during a time of year other than the fishing season. The population decreases during the fishery season because of the catch removals only).

Log books:

Leslie analysis of CPUE and cumulative catch data from log books [Table 3, Fig. 4] gave estimates for catchability (q) and initial commercial biomass (B_0) of 2.682×10^{-4} and 69.44 MT (95% confidence limits: 45.2 and 237.4 MT), respectively. The serrated pattern of the data points in Fig. 4 is probably due to fishermen being able to move effort to more productive virgin grounds when CPUE decreased on their existing fishing ground. Total catch during the 1979 fishing season was 27.38 MT, to give an exploitation rate of 39.4% (95% confidence limits: 11.5 and 60.6%) (F values: 0.50, 0.12-0.93). By subtraction of the catch from the total biomass, 42 MT (95% confidence limits 17.8 and 210.0 MT) of commercial crabs remained on the fishing grounds at the end of the season.

Area 12 (southwestern Cape Breton)

Southwestern Cape Breton, area 12, opened for commercial snow crab fishing by Cape Breton boats for the first time in 1979. This fishery is unique in that the grounds are in shallow water compared to other Cape Breton snow crab fishing areas [Fig. 1].

Port and at-sea sampling:

At-sea sampling in area 12 was carried out from commercial boats in July and August, 1979 [Fig. 5]. Figure 5 also shows port sampling data for August 1979. From the at-sea sampling, mean male crab carapace width decreased from 95.4 mm in July to 94.0 mm in August. Population size structure appeared polymodal and modes may represent separate moult classes. We have no information on the proportion of soft-shelled crabs in the area 12 population throughout the fishing season.

Log books:

CPUE plotted against cumulative catch data [Table 4], derived from log books belonging to 13 of the 14 inshore permit holders in the area 12 fishery is shown in Fig. 6.* The general serrated pattern of the data points probably reflects non-uniform fishing effort on a virgin stock. As moulting continues to the second week of August in the adjacent snow crab fishing area 8, it is reasonable to assume that the general rise in CPUE during the initial 5 weeks of the area 12 fishing season, despite the removal of 119.9 MT by the fishery during this period, was due to recruitment through moulting and growth. The data for the final 8 weeks of the fishing season shows a general decrease in CPUE. By the Leslie method, a linear regression through these final 8 data points gives an estimate of usable stock (B), as the intercept on the x-axis, of 428.0 MT (95% confidence limits: 314.5 and 1301.4 MT). The total catch (Y) through the fishing season was 212.8 MT. Thus, 215.2 MT of the usable stock was left on the grounds when the fishery closed (95% confidence limits: 101.7 MT and 1088.5 MT); corresponding to an exploitation rate of 49.7% (95% confidence limits: 67.7% and 16.4%) (F values: 0.69, 1.13-0.18).

*Caution: snow crab boats from New Brunswick probably fished in area 12 during the 1979 fishing season. As log books from the New Brunswick boats are unavailable, the area 12 catch may be grossly under-represented with subsequent errors in the Leslie biomass estimate.

Assuming catchability (q) remained constant throughout the fishing season, a CPUE of 37.3 kg/trap haul obtained in the first week of the season corresponds to an available biomass (B_1) of 200.1 MT. Given that the total biomass (B) usable by the fishery was 423 MT we can estimate that 227.9 MT was recruited to the fishable stock during the first 5 weeks of the season. This contribution is 113.9% of the initial biomass (B_0) and 53.2% of the total (B).

Area 8 (northwestern Cape Breton)

The commercial snow crab fishery in northwestern Cape Breton started in the late 1960's, with exploitation by offshore boats from Quebec and New Brunswick. By 1978 the area 8 snow crabs were being wholly exploited by inshore boats from northwestern Cape Breton ports. A quota of 1406 MT was set for area 8 in 1979. Bailey (1978b) presents an assessment for the northwestern Cape Breton snow crab fishery in 1978. The 1979 assessment is presented below.

Port and at-sea sampling

Catch size-frequency histograms for male snow crabs were obtained from in-port sampling carried out in July and August for 1977, 1978 and 1979 [Fig. 7]. Histograms of catch size frequencies from at-sea sampling carried out in August and September, 1977 and July and August, 1979 are shown in Fig. 8. Although distinct modes are apparent in the 1977 size frequencies, none are obvious in the 1978 and 1979 data. Values for mean carapace width of snow crabs, for both at-sea and in-port samples, indicate that there has been a decrease in the average size of crabs caught in area 8 over the past 3 years. Data for frequency of occurrence of soft-shelled crabs, as determined from port samples, in 1979 indicate a moulting peak from late July to mid-August [Fig. 9].

Log books:

Analysis of the 1979 log books from all 27 of the licensed area 8 snow crab fishermen was performed by the Leslie method [Fig. 10].* The relatively stable CPUE during the initial 6 weeks of the season, despite significant landings, probably reflects growth and recruitment, through moulting, into the fishery. This phenomenon is reflected in our 1979 data for the frequency of occurrence of soft-shelled crabs in the landed catch [Fig. 9]. Similarly, Bailey (1978b) reported a constant addition of biomass

*During August and September of the 1979 snow crab fishing season it is possible that 5 boats from area 10 may have fished in area 8 and caught an estimated 93,431 kg (which was subsequently recorded as being fished from area 10). These landings represent approximately 6.3% of total 1979 landings from bona fide area 8 boats. Log books from the area 10 boats in question are unavailable and we are, therefore, unable to compensate for the actions of these area 10 boats in the area 10 or the area 8 biomass estimates. Hence, it should be recognized that the area 8 biomass estimates may be slight underestimates, whereas the area 10 biomass estimates may be slight overestimates (exploitation values should be unaffected for both areas).

into the stock during this same period in 1978. A linear regression through the data for the final 8 weeks of the 1979 season, after the estimated pulse of growth and recruitment, gives an estimate of usable stock of 2238.7 MT (95% confidence limits: 1734.2 and 2713.5 MT). By subtraction of the total 1979 catch for area 8, 1390.8 MT (derived from log books, Table 5), we estimate that 847.9 MT (95% confidence limits: 343.4 and 1322.7 MT) of commercial snow crabs were left on the grounds when the fishery closed. If natural mortality was not significant during the fishing season this catch is equivalent to an exploitation rate of 62.1% (95% confidence limits: 30.2% and 81.3%) (F values: 0.97, 1.62-0.72).

The first week of the 1979 fishing season was disrupted by a hurricane; hence we have treated CPUE data from this period as anomalous. For the second week of the season the mean CPUE was 75.1 kg/trap haul, giving an estimate of fishable stock present at this time as 1294.4 MT (from $B = CPUE/q$). The catch during the first week of the season was 154.3 MT, thus the estimated initial stock at the beginning of the season was $(1294.4 + 154.3)$ MT = 1448.7 MT. Given that 2238.7 MT was the total usable stock, this estimate of initial stock corresponds to a net stock increase of 790 MT from growth and recruitment during the fishing season. This stock increase represents 54.5% of the initial available biomass and 35.3% of the total. Bailey (1978b) determined a 1,189 MT net stock increase from growth and recruitment during the 1978 fishing season; this represented 65.1% of the initial available biomass and 39.4% of the total.

Bailey (1978b) calculated that 1075 MT of usable stock remained on the area 8 grounds at the close of the 1978 fishing season. Thus, a difference of 373.7 MT (34.8% of the stock left at the end of 1978) is estimated to have been added to the grounds, presumably through recruitment and growth, between the end of the 1978 fishing season and the start of the 1979 season.*

Tagging:

During the second and third week of the 1978 fishing season, Bailey (1978b) tagged 3,951 male snow crabs in area 8. 1,777 of these tagged animals were recaptured during the remainder of the 1978 fishing season. Subsequently, a further 119 of the tagged crabs were recovered during the 1979 fishing season (3 of the 119 tags were ignored due to lack of information on date of capture). Data from these 1979 recoveries [Table 6] have been analyzed by the Leslie method (see Bailey 1978b for details) to provide estimates of rate of fishing, survival rate, and instantaneous rate of total mortality [Fig. 11, Table 7.]. For comparison, Table 7 shows survival and mortality estimates based on 1978 tag returns (Bailey 1978b) as well as calculations for the 1979 returns. Estimates, from the 1979 tagging data, for $F(0.79)$, the rate of fishing, 54.7%, and catchability (q), 4.456×10^{-5} , compare with values of 0.97, 62.1% and 5.802×10^{-5} , respectively, derived from the 1979 log book data.

*An alternative explanation is that fishermen in 1979 fished a larger area than in 1978, resulting in misleadingly high CPUE's in 1979 and the Leslie biomass estimates giving a false indication of between season recruitment and growth.

Calculations of biomass with the Peterson method, using the 1979 tag returns, were not feasible as all the tagged crabs were recaptured during the early part of the season when recruitment and growth were occurring.

Figure 12 shows the size frequency of tagged crabs recaptured during the 1979 fishing season. It is apparent that it was not only the largest tagged animals that had not moulted in the intervening period between tagging and recapture. This data may indicate that relatively small males may miss annual moults, or reach a terminal moult stage well below the generally accepted maximum size (L_{∞}) of 155 mm carapace width. A similar observation was made by Watson (1970b). Tag recaptures were all in the general area of release.

Data on the size frequency of soft-shelled crabs was too unreliable to be used to calculate the separate contributions of growth and recruitment to increases in stock size during the fishing season.

Area 10 (northeastern Cape Breton)

The snow crab fishery in area 10, northeastern Cape Breton, started in 1976. Log book data from the 1978 and 1979 fishing seasons are here analyzed, together with catch size-frequency data from 1977 and 1979.

Port and at-sea sampling:

Catch size-frequency distributions from in-port sampling during July, August and September 1977 and 1979, and at-sea sampling during August 1977 and June and August 1979 are shown in Figs 13, 14 and 15. Comparison of the in-port sampling data shows an increase in mean male crab carapace width from 1977 to 1979. In contrast, at-sea sampling data demonstrates a decrease in mean male crab carapace width during the same period. Figure 16 shows an increase in the percentage frequency of occurrence of soft-shelled male crabs in the catch towards the end of the 1979 fishing season.

Log books:

Area 10 fishermen use wooden 4x3x2.5 ft (1.2x0.9x0.8 m) and Japanese conical traps, as well as some metal rectangular traps. Therefore, to standardize the unit of effort for CPUE purposes, all trap data was converted to square wooden trap units (Bailey 1978b) as these were the most common trap in area 10.

1978: As the 27 log books forthcoming from area 10 fishermen in 1978 represented only 58% of the total landings no biomass estimates have been made on these data. However, CPUE plotted against cumulative catch data [Table 8, Fig. 17] indicate an increase in stock size, probably due to moulting and recruitment, in the latter part of the season. The timing of this additional pulse of biomass is in accord with data derived from 1979 log books and observations on the frequency of occurrence of soft-shelled crabs in the catch [Fig. 16].

1979: 40, out of possible 48, log books were received from the area 10 licensed fishermen in 1979.* A linear regression through the initial 4

*See footnote p. 6.

weeks of data [Table 9, Fig. 18] gives an initial biomass (B_0) estimate of 324.9 MT (95% confidence limits: 290.9 and 374.6 MT) and a catchability (q) of 5.3009×10^{-5} . The final 6 weeks of the season show a rapid rise and fall in CPUE, presumably due to recruitment and growth during this period. Assuming that catchability (q) was constant throughout the fishing season, an estimate of total usable biomass (B_T) can be made from:

$$B_T = \frac{CPUE_T}{q} = \frac{22.6}{5.3009 \times 10^{-5}} = 426.3 \text{ MT}$$

where: q = catchability throughout the fishing season.

$CPUE_T$ = the intercept on the Y-axis of a line, parallel to the linear regression, through the peak CPUE data point at the end of the estimated period of recruitment and growth [Fig. 18].

Given a total catch of 262.3 MT for area 10 during the 1979 fishing season we can estimate that 164.0 MT of usable stock were left on the fishing grounds at the end of the season. This corresponds to an exploitation rate of 61.5% ($F=0.95$) of the total usable biomass and 80.7% of the initial biomass.

Recruitment and growth (R) during weeks 5-8 of the fishing season can be estimated from:

$$R = B_T - B_0 = 426.3 - 324.9 = 101.4 \text{ MT}$$

This is 31.2% of the initial available stock (B_0) and 23.8% of the total (B_T).

Tagging:

In area 10 a total of 1,077 male snow crabs were tagged and released (between: Latitude $46^{\circ}50'$, Longitude $60^{\circ}10'$; and Latitude $46^{\circ}40'$, Longitude $60^{\circ}06'$) between 19 and 21 June, 1979, approximately one month before the fishery opened. Although 39.5% of the crabs tagged were under the legal minimum size limit, 95 mm carapace width, only 13.9% (20) out of the 144 tagged crabs recovered were under 95 mm carapace width. Figure 19 illustrates the size frequency of both crabs tagged and recaptured crabs with tags. It is apparent that relatively more of the larger tagged crabs were recaptured, compared to the number of recaptured smaller tagged crabs. This phenomenon is probably due to a decreased propensity for the larger animals to moult, and thus lose their tags. Therefore, we present two separate linear regressions and Leslie analyses of the tagging data (Table 10) for consideration:

1) Figure 20 includes the data for all sizes of tagged crabs. Analysis of these data [Table 11] gives an exploitation rate of 70.8% and a catchability (q) of 6.973×10^{-5} . Using the Peterson method of biomass estimation for the usable stock (B_1) in the first week of the fishing season (using data for the first 4 weeks only to avoid errors caused by the pulse

of growth and recruitment detected in the log book and port sampling records):

$$B_1 = \frac{C(1-4) \times M_1}{R(1-4)} = \frac{197 \times 209}{109} = 378.1 \text{ MT}$$

Where $C(1-4)$ = total catch during weeks 1-4

M_1 = apparent total number of crabs tagged

R_{1-4} = total number of tagged crabs recaptured during weeks 1-4

2) In Fig. 20, crabs below 95 mm carapace width have been excluded from the analyses due to their comparatively greater tendency to moult. An exploitation rate of 68.3% was obtained with a catchability (q) of 6.45×10^{-5} for these data [Table 10]. The Peterson method of biomass estimation, for the first week gives:

$$B_1 = \frac{C(1-4) \times M_1}{R(1-4)} = \frac{197 \times 183}{91} = 396.5 \text{ MT.}$$

It is noteworthy that for both tagging data treatments [Table 10] there were very low numbers of tags returned during the initial 2 weeks of the fishing season. This may have been a result of the tagged animals not spreading out over the fishing grounds, and the fishermen not expending much effort in the areas where there were tagged crabs. (This situation should result in an overestimation of biomass in the Peterson analyses for area 10; however, Peterson estimates are comparable with the Leslie biomass estimates from log book data). Because of the initially low numbers of tag returns, linear regressions [Fig. 20] do not take into consideration data points for the initial 2 weeks of the fishing season. No significant movements were indicated from the tag recaptures.

Area 9 (southeastern Cape Breton)

The snow crab fishery in southeastern Cape Breton begun in 1977. Log book data from the 1978 and 1979 fishing seasons are analyzed here, together with catch size-frequency data from 1978 and 1979.

Port and at-sea sampling:

Catch size-frequency histograms from in-port sampling of catches during July and August 1978 and 1979; and at-sea sampling during August, 1978 and July and August, 1979 are shown in Figs 21 and 22. Mean male crab carapace width appeared to decrease dramatically between July and August, 1979 for both at-sea and in-port samples. From the at-sea sampling of size frequencies it is apparent that this decrease may have been due to a pulse of recruitment in August. No reliable data on the percentage frequency of occurrence of soft-shelled crabs in the catch is available for area 9 in 1978 or 1979.

Log books:

1978: As the 15 log books collected from the 15 area 9 fishermen represented only 63% of their total 1978 landings little reliability should be placed in the following 1978 biomass estimates. CPUE plotted against cumulative catch

data [Table 12, Fig. 23] enables an initial usable biomass (B_0) estimate of 440 MT (95% confidence limits: 351.5 and 637 MT) to be made by the Leslie method. Total catch during the 1978 fishing season, as estimated from log books, in area 9 was approximately 250 MT, to give an exploitation rate of 56.8% (95% confidence limits: 71.2% and 39.3%; F values: 0.84, 1.24-0.50). By subtraction, 190 MT (95% confidence limits: 101.5 and 387 MT) of usable stock is estimated to have been left on the fishing grounds at the end of the 1978 season. Because of the generally regular decline in CPUE in Fig. 23, no pulse of recruitment appears to have obviously occurred during the fishing season.

1979: 14 log books were received from the 15 snow crab fishermen in area 9 in 1979. In addition, the log books from 9 fishermen with offshore permits are included in the following analyses, as they may have been fishing in inshore area 9. Leslie analysis, based on a linear regression through all data points for the season [Table 13; Fig. 24] gives an estimate of initial usable biomass (B_0) of 1,185 MT (95% confidence limits: 1,060 and 1,367 MT). [The rise in CPUE between weeks 4-6 may have been due to an addition of biomass from growth and recruitment; however, this possibility was ignored in the biomass estimates]. With a total catch during the 1979 fishing season of 683 MT, exploitation rate can be estimated at 57.5% (95% confidence limits: 64.3% and 49.9%) (F values: 0.86, 1.03-0.69). 502 MT (95% confidence limits: 377 and 684 MT) are estimated to have been left on the grounds at the end of the 1979 fishing season.

The estimate of initial biomass (B_0) at the start of the 1979 fishing season, 1,185 MT, is considerably greater than the estimated biomass of 190 MT remaining at the end of the 1978 season, and argues that considerable winter recruitment and growth could have occurred between the seasons.*

Tagging:

In area 9, a total of 2,010 male snow crabs were tagged between 4-5 July, 1979 (between: Latitude 45°38', Longitude 59°43' and Latitude 45°43', Longitude 59°59'). The majority, 1,812, of the crabs tagged were in a hard-shelled condition; the 173 and 25 crabs making up the remainder were judged to be in intermediate and soft-shelled states, respectively. Figure 26 shows the size frequency of all the crabs tagged and the size frequency of the recaptured animals. The similarity between the two size frequencies suggests that differential tag loss in the smaller crab sizes due to moulting was negligible. A total of 1,444 tagged crabs were recovered during the 1979 fishing season [Table 14]. A Leslie analysis of the tagging data [Fig. 25; Table 15] [excluding a set of 745 doubtful tag returns and the abnormally high returns (15) during the final week of the season] gives an exploitation rate of 64.5% (95% confidence limits: 80.4% and 42.9%) and a catchability (q) of 6.733×10^{-5} . A Peterson estimate of biomass (B_1) can be obtained for the initial week of the fishery:

$$B_1 = \frac{C_{1-10} \times M_1}{R_{1-10}} = \frac{674.5 \times 1084}{684} = 1,069 \text{ MT}$$

*Assuming that no changes in the grounds fished occurred between the 1978 and 1979 fishing seasons.

where: C_{1-10} = Catch in weeks 1-10 of the fishing season
 M_1 = Apparent number of animals tagged
 R_{1-10} = Number of tags returned during weeks 1-10 of the fishing season.

These tagging estimates of exploitation rate, catchability and biomass compare favourably with estimates derived from log book data. However, it should be taken into account that if significant moulting occurred during the fishing season (as catch size-frequency histograms indicate, Fig. 26) biomass calculations from tagging and log book data will be overestimates. All recaptured tagged animals were in the general area of release.

SUMMARIES AND TENTATIVE FORECAST FOR 1980

Area 11

For area 11 in 1979 the exploitation rate was 63% (95% confidence limits: 70% and 56%). 290 MT (95% confidence limits: 218 and 391 MT) is estimated to have been left on the grounds at the close of the 1979 fishing season. No information on growth, the rate of recruitment or moulting are available for this stock; none appeared to have occurred during the 1979 fishery season.

Area 13

This area supports a new, relatively small-scale fishery. Exploitation during the 1979 fishing season was at 39% (95% confidence limits: 13.5% and 61%); leaving 42 MT (95% confidence limits: 18 and 176 MT) at the end of the season. We have no information on stock recruitment and moulting.

Area 12

This area supports a new fishery, in comparatively shallow water. Management decisions are made difficult by the wide confidence limits for biomass and exploitation rate estimates. During the 1979 fishing season the exploitation rate of the total usable biomass was 50% (95% confidence limits: 68% and 16%); and 215 MT (95% confidence limits: 102 and 1,089 MT) were estimated to have been left the grounds at the end of the season. During the 1979 fishing season there was a pulse of recruitment and growth estimated at 114% of the biomass available at the start of the season. Given the same rate of recruitment during 1980, the total biomass available to the fishery will be 460 MT (this compares favourably to the 423 MT available to the 1979 fishery).

Area 8

During 1979 exploitation rate was estimated at 62% (95% confidence limits: 80% and 51%) from log book data, and at 55% from a Leslie analysis of tagging data. 848 MT (95% confidence limits: 343 and 1,323 MT) were estimated to have been left on the grounds at the close of the 1979 fishing season. During the 1979 season a growth and recruitment pulse estimated at 790 MT (54.5% of the initial biomass) occurred; a similar pulse of 1,189 MT,

equivalent to a 65% addition of biomass occurred in 1978 (Bailey 1978). Recruitment and growth between the 1978 and 1979 fishery seasons may have increased stocks by 35% (374 MT).

As the relative contributions of recruitment, by individuals moulting to legal size, and growth, of commercial crabs, to biomass increase in the fishable stock are uncertain,* the following forecasts have been determined by 1) constant percentage increases in stock and 2) actual biomass increases based on the 1979 levels:

1) On the basis of constant percentage increases, and given a similar rate of winter recruitment (35%) to 1978-79 between the 1979 and 1980 seasons plus a biomass pulse of 54.5% during the 1980 season, we can estimate a total available biomass for the 1980 season of 1,769 MT.

2) On the basis of actual biomass increases, 374 MT would be added between the 1979 and 1980 seasons and 790 MT would be added during the initial part of the 1980 season. Total available biomass would be 2,012 MT for the 1980 season.

The TAC for 1979, 1,406 MT, was partly based on the premise of taking the weight from growth and recruitment without affecting standing stock at the end of the year; a similar management strategy for 1980 (assuming that between-season growth and recruitment is a real phenomenon) would result in a TAC of 921 MT (based on constant percentage increases in stock size) or 1,164 MT (based on actual increases). Due to the lack of soundly based biological information on snow crab growth and recruitment and the uncertainty regarding between-season biomass increases, the former, more conservative, TAC may be the most prudent.

Total biomass available during the fishing season, estimated from log book data, has declined from 3,016 MT in 1978 to 2,239 MT in 1979, and at the present level of exploitation will probably decline still further in 1980.

Area 10

Biomass remaining at the end of the 1979 fishing season was estimated, from log books, at 164 MT, corresponding to an exploitation rate of 61.5%. Estimates of biomass remaining at the end of the fishing season and exploitation rates, from a Peterson treatment of tagging data, vary between 116-134 MT, and 69-66%, respectively. Leslie analysis of tagging data gives an exploitation rate of 71%. The biomass at the start of the 1979 season was supplemented by an additional 31% during the fishing season. Assuming no winter recruitment, and a similar biomass addition in the 1980 season, 216.5 MT (based on the log book estimation of biomass) should be available to the 1980 fishery; this compares unfavourably to the 426 MT available to the 1979 fishery.

*Bailey (1978b) approximately estimated that 84% of the biomass increase was due to recruitment and 16% was due to growth.

Area 9

From log book data, 502 MT (95% confidence limits: 377 MT and 684 MT) of usable stock was calculated to have remained on the fishing grounds at the end of the 1979 season; corresponding to an exploitation rate of 57.5% (95% confidence limits: 64% and 50%). From Leslie analysis of tagging data the exploitation rate is estimated at 64.5%. Similarly, from a Peterson estimate of biomass of 1,069 MT during the first week of the fishery, 386 MT is estimated to have been left on the grounds at the end of the fishing season, an exploitation rate of 64%. As no reliable estimates on recruitment and growth rate are available for area 9 (due to the errors inherent in the 1978 biomass analyses) prognoses on biomass availability for the 1980 season are not feasible at this stage.

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Table 1. Snow Crab Statistics for Cape Breton 1977, 1978 and 1979

Area	Year	No. of boats	Kg landed (log books)	Kg landed Area Stats	Effort in trap hauls from log books (trap type)	Quota in M.T.	Commercial biomass (B) estimates from Leslie analysis of (B) from log books (95% confidence limits)			Prediction of B for following season (M.T.)	Fishing season
							Exploitation rate log book tagging (95% confidence limit)	Total available B for the season (M.T.)	B at the end of the season (M.T.)		
0	1977	0*	-	-	-	-	-	-	-	-	June-30/79
northwest	1978	14*	1,941,000	-	26,401 (1.5x1.5x0.5 m)	-	64.4% (55-71)	3016 (2722-3555)	1075 (700-1592)	2100 (1063-2759)	22/6-30/9
	1979	27*	1,390,665	1,390,016	20,416 (1.5x1.5x0.5 m)	1,406	62.1% (51-80)	2200.7 (1714-2714)	840 (343-1323)	1769 (-)	1/7-30/9
	1978	15*	250,076	-	4,531 (1.5x1.5x0.5 m)	-	57% (39-71)	440 (352-617)	190 (102-307)	-	July-30/9
9 + offshore southeast	1979	15+10(?)	682,731	495,435 (no offshore)	14,747 (1.5x1.5x0.5 m)	-	57.5% (50-64)	1105 (1000-1307)	502 (377-604)	-	20/7-30/9
10	1977	25 (?)	-	-	-	-	-	-	-	-	-
northeast	1978	27 (16)*	192,278	-	17,258 (1.2x0.9x0.8 m)	-	-	-	-	-	July-30/9
	1979	40 (48)*	262,250	293,106	25,660 (1.2x0.9x0.8 m)	-	61.5% (47-71)	426 (-)	164 (-)	216.5 (-)	20/7-30/9
11 + offshore middle east	1979	14(10)+12(?)	507,569	469,600 (no offshore)	10,546 (1.5x1.5x0.5 m)	-	64.2% (40.6-56.9)	790 (710-891)	283	-	20/7-30/9
	1979	15*	212,000	211,426	4,449 (1.5x1.5x0.5 m)	-	49.7% (47.7-51.6)	428 (114.5-130)	215.2	-	1/7-30/9
13 south	1979	0*	27,151	24,868	1,000 (1.5x1.5x0.5 m)	-	39.4% (11.5-60.6)	69.46 (45.2-237.4)	42	-	21/7-30/9
	1979	15(27)*	324,048	310,499	6,212 (1.5x1.5x0.5 m)	-	-	-	-	-	21/7-30/9

*Actual number of boats

(?) Probably lower than the actual number of boats.

Table 2. Catch and effort statistics for the snow crab fishery in area 11 (middle east Cape Breton) 1979.

Week period	Effort (trap hauls) steel traps (1.5x1.5x0.5 m)	CPUE (kg/trap haul)	Catch (MT)	Estimated* biomass (MT)
1. 21-28 July	1496	71.0	106.2	742
2. 29 July-4 August	1686	62.8	105.8	656
3. 5-11 August	1229	46.9	57.7	490
4. 12-18 August	1336	46.3	61.8	484
5. 19-25 August	1615	45.3	73.2	473
6. 26 Aug.-1 Sept.	1089	34.2	37.3	357
7. 2-8 Sept.	862	32.8	28.3	343
8. 9-15 Sept.	368	29.6	10.9	309
9. 16-22 Sept.	436	28.2	12.3	295
10. 23-29 Sept.	429	33.0	14.2	345
Total	10546	-	507.6	-

$$\text{*Estimated biomass} = \frac{\text{CPUE}}{q}$$

q = catchability coefficient from Leslie analysis.

Table 3. Catch and effort statistics for the snow crab fishery in area 13
(south Cape Breton) 1979.

Week period	Effort (trap hauls) steel traps (1.5x1.5x0.5 m)	CPUE kg/trap haul	Catch (MT)	Estimated biomass (MT)
1. 21-28 July	149	22.1	3.3	82
2. 29 July-4 August	154	16.6	2.6	62
3. 5-11 August	157	13.8	2.2	51
4. 12-18 August	164	16.6	2.7	62
5. 19-25 August	208	13.7	2.9	51
6. 26 Aug.-1 Sept.	269	13.0	3.5	49
7. 2-8 Sept.	200	14.8	3.0	55
8. 9-15 Sept.	178	11.9	2.1	44
9. 16-22 Sept.	183	14.7	2.7	55
10. 23-29 Sept.	218	11.7	2.5	44
Total	1880	-	27.4	-

Table 4. Catch and effort statistics for the snow crab fishery in area 12 (southwestern Cape Breton) 1979.

Week period	Effort (trap hauls) steel traps (1.5x1.5x0.5 m)	CPUE (kg/trap haul)	Catch (MT)	Estimated biomass (MT)
1. 1-7 July	164	37.3	6.1	200
2. 8-14 July	548	36.1	19.7	194
3. 15-21 July	515	53.0	27.3	284
4. 22-28 July	518	48.1	24.9	258
5. 29 July-4 Aug.	507	50.9	25.8	273
6. 5-11 August	263	61.0	16.0	327
7. 12-18 August	326	50.7	16.5	272
8. 19-25 August	596	50.2	29.9	269
9. 26 Aug.-1 Sept.	307	52.5	16.1	282
10. 2-8 September	342	46.6	15.9	250
11. 9-15 September	108	48.8	5.3	262
12. 16-21 September	120	41.5	5.0	223
13. 22-28 September	135	30.7	4.2	165
Total	4449	-	212.7	-

Table 5. Catch and effort statistics for the snow crab fishery in area 8 (northwestern Cape Breton) 1979.

Week period	Effort (trap hauls) steel traps (1.5x1.5x0.5 m)	CPUE (kg/trap haul)	Catch (MT)	Estimated biomass (MT)
1. 2-7 July	2225	69.3	154.3	1194
2. 8-14 July	3861	75.1	290.1	1294
3. 15-21 July	4185	73.5	307.6	1267
4. 22-28 July	3468	71.9	249.2	1239
5. 29 July-4 Aug.	2715	62.7	170.1	1081
6. 5-11 August	909	64.7	58.8	1115
7. 12-18 August	962	50.6	48.7	872
8. 19-25 August	930	56.3	52.4	970
9. 26 Aug.-1 Sept.	460	46.0	21.2	793
10. 2-8 September	434	54.3	23.6	936
11. 9-15 September	158	55.9	8.8	963
12. 16-22 September	69	49.9	3.4	860
13. 23-29 September	60	45.2	2.7	779
Total	20436	-	1390.7	-

Table 6. Number of tag returns from the snow crab fishery in area 8
(northeast Cape Breton) 1979

Week period	Number of tag returns
1. 1-7 July	22
2. 8-17 July	30
3. 15-21 July	21
4. 22-28 July	11
5. 29 July-4 August	19
6. 5-11 August	7
7. 12-18 August	5
8. 19 August - 1 September (2 weeks)	0
9. 2-8 September	1
Total	116*

*A further 3 tags were returned but are ignored in the analyses due to lack of information on date of capture.

Table 7. Survival and mortality estimates for tagging study in area 8
(northwest Cape Breton) 1979

Estimates	Total crabs
Estimated number of tagged crabs left at end of 1978 fishing season (M)	946
Apparent number marked (M')	212
(limits of confidence at $P=.05$)	(131-425)
Number recaptured: (R)	116
Rate of fishing: (R/M-X)	0.123
Rate of fishing: (R/M')	.547
	(.885-273)
Estimated number remaining: (M'-R)	96
	(15-309)
Survival rate: ($S' = M'-R/M-X$)	.101
	(.016-.327)
Instantaneous rate of total mortality ($Z' = -\ln S'$)	2.29
	(4.14-1.12)
Disappearance (numbers) from other causes: ($X' = M-X-R-(M'-R)$)	734
Rate of disappearance from other causes: ($X'/M-X$)	.776

Table 8. Catch and effort data for the snow crab fishery in area 10, northeastern Cape Breton 1978.

Week period	EFFORT (trap hauls)			CPUE (kg/trap hauls) (combined and wooden (1.5x.9x.8 m))	Catch (MT)	Estimated biomass (MT)
	Combination of conical and wooden traps* (1.5x.9x.8 m)	Large steel traps (1.5x1.5x0.5 m)	All traps converted to wood/conical			
1. 26 June-2 July	120	-	120	14.3	1.7	212
2. 3-9 July	448	-	448	15.6	6.9	232
3. 10-16 July	433	-	433	12.4	5.4	184
4. 17-23 July	1162	136	1523	13.8	21.0	205
5. 24-30 July	2168	285	2726	12.5	34.2	186
6. 31 July-5 Aug.	2542	259	3286	10.1	33.2	150
7. 6-12 August	2854	179	3561	7.7	27.3	114
8. 13-19 August	3090	222	1320	9.2	12.2	137
9. 20-26 August	420	243	995	9.5	9.4	141
10. 27 July-2 Aug.	442	268	997	11.7	11.7	174
11. 3-9 Sept.	284	215	609	16.2	9.9	241
12. 10-16 Sept.	258	166	417	15.8	6.6	235
13. 17-23 Sept.	284	237	529	13.7	7.3	204
14. 24-30 Sept.	70	213	294	12.9	3.8	192
15. 1-7 Oct.	-	165	-	-	1.8	-
Total	14575	2588	17258	-	192.2	-

*Assumed conical traps = wooden traps.

Table 9. Catch and effort data for the snow crab fishery in area 10, northeastern Cape Breton 1979.

Week period	EFFORT (trap hauls)					CPUE kg/trap haul (wooden traps)	Catch (MT)	Estimated biomass (MT)
	Large square wooden traps (1.2x0.9x0.8 m)	Conical traps	Large steel traps (1.5x1.5x.5 m)	More than one type fished by same boat	All traps converted into wooden traps			
1. 21-28 July	1404	478	180	2534	5806	14.8	85.9	279
2. 29 July-4 Aug.	1328	416	185	2731	4487	11.6	51.9	219
3. 5-11 August	1264	558	110	1867	4014	8.9	35.6	168
4. 12-18 August	1022	409	100	1646	3237	7.3	23.6	138
5. 19-25 August	830	295	130	1446	2746	7.4	20.3	140
6. 26 Aug.-1 Sept.	761	118	120	1123	2148	8.1	17.4	153
7. 2-8 Sept.	636	297	115	295	1213	8.9	10.8	168
8. 9-15 Sept.	287	242	22	170	678	9.5	6.4	179
9. 16-22 Sept.	360	168	28	180	699	8.7	6.1	164
10. 23-29 Sept.	287	248	17	108	632	6.4	4.1	121
Total:	8183	3229	1007	12100	25,660	-	262.3	-

Table 10. Number of tag returns from the snow crab fishery in area 10, northeastern Cape Breton 1979.

Week period	No. of tagged returns from all tagged crabs	No. of tagged returns from tagged crabs over 95 mm
1. 7-28 July	16	15
2. 29 July-4 Aug.	24	21
3. 5-11 August	36	32
4. 12-18 August	33	23
5. 19-25 August	17	14
6. 26 Aug.-1 Sept.	16	14
7. 2-8 September	4	4
8. 9-15 September	2	2
9. 16-22 September	-	-
10. 23-29 September	-	-
Total	148	125

Table 11. Survival and mortality estimates for the tagging study in area 10, northeastern Cape Breton, 1979.

Estimates	Total no. of tagged crab returns	Total no. of tagged crab returns over 95 mm
Initial number marked: (M)	1077	653
Mortality (numbers) from marking: X' (rate observed experimentally in 1978)	124 (.115)	75 (.115)
Actual number marked: (M-X)	953	578
Apparent number marked (M') (limits of confidence at $P=.05$)	209 (157-16409)	183 (142-559)
Number recaptured: (R)	148	125
Rate of fishing: (R/M-X)	.155	.216
Rate of fishing: (R/ M')	.708 (.746-.013)	.683 (.880-.224)
Estimated number remaining: ($M'-R$)	61 (2-16261)	58 (17-434)
Survival rate: ($S' = M'-R/M-X$)	.064 (.002-17.1)	.100 (.029-.751)
Instantaneous rate of total mortality ($Z' = -\ln S'$)	2.75 (6.17-2.84)	2.30 (3.53-0.29)
Disappearance (numbers) from other causes: ($X' = M-X-R-(M'-R)$)	744 (803-15456)	395 (436-19)
Rate of disappearance from other causes: ($X'/M-X$)	.781 (.843-16.2)	.683 (.754-.033)

Table 12. Catch and effort statistics for the snow crab fishery in area 9 southeast Cape Breton, 1978.

Week period	Effort (trap hauls) with steel traps (1.5x1.5x0.5 m)	CPUE (kg/trap haul)	Catch (MT)	Estimated biomass (MT)
1. 16-22 July	140	93.4	13.1	498
2. 23-29 July	460	77.6	35.7	414
3. 30 July-5 Aug.	637	67.6	43.1	361
4. 6-12 August	551	55.8	30.8	294
5. 13-19 August	230	52.7	12.1	281
6. 20-26 August	370	46.6	17.3	249
7. 27 Aug.-2 Sept.	491	47.2	23.2	252
8. 3-9 Sept.	449	42.7	19.2	228
9. 10-16 Sept.	304	51.0	15.5	272
10. 17-23 Sept.	539	41.6	22.4	222
11. 24-30 Sept.	360	49.7	17.9	265
Total	4531	-	250.1	-

Table 13. Catch and effort statistics for the snow crab fishery in area 9
southeast Cape Breton, 1979.

Week period	Effort (trap hauls) with steel traps (1.5x1.5x0.5 m)	CPUE kg/trap haul	Catch (MT)	Estimated biomass (MT)
1. 21-28 July	1469	69.5	102.1	1187
2. 29 July-4 August	2022	58.5	118.5	999
3. 5-11 August	1674	51.6	86.4	881
4. 12-18 August	1616	48.2	77.9	823
5. 19-25 August	1829	49.4	90.3	844
6. 26 Aug.-1 Sept.	1441	34.9	50.2	596
7. 2-8 Sept.	1365	35.8	48.8	612
8. 9-15 Sept.	1190	32.0	38.0	547
9. 16-22 Sept.	931	33.4	31.1	571
10. 23-29 Sept.	990	31.3	31.1	535
11. 30 Sept.-8 Oct.	220	33.9	7.5	579
Total	14747	-	681.9	-

Table 14. Number of tag returns from the snow crab fishery in area 9, southeast Cape Breton, 1979.

Week period	Total number of tagged crab returns (excluding 760 unreliable tag returns)
1. 22-28 July	86
2. 29 July-4 August	122
3. 5-11 August	114
4. 12-18 August	86
5. 19-25 August	101
6. 26 Aug.-1 Sept.	52
7. 2-8 September	40
8. 9-15 September	37
9. 16-22 September	19
10. 23-29 September	27
Total	684

Table 15. Survival and mortality estimates for the tagging study in area 9, southeast Cape Breton, 1979

Estimates	Total no. of crabs tagged (less unreliable returns)
Initial number marked: (M)	1250
Mortality (numbers) from marking: (X) (rate observed experimentally)	144 (.115)
Actual number marked: (M-X)	1106
Apparent number marked (M') (limits of confidence at P=.05)	1084 (868-1628)
Number recaptured: (R)	684
Rate of fishing: (R/M-X)	.618
Rate of fishing: (R/M')	.631 (.788-.420)
Estimated number remaining: (M'-R)	400 (184-944)
Survival rate: ($S' = M'-R/M-X$)	.362 (.166-.854)
Instantaneous rate of total mortality ($Z' = -\ln S'$) for the 10-week period	1.02 (1.794-.158)
Disappearance (numbers) from other causes: ($X' = M-X-R-(M'-R)$)	22
Rate of disappearance from other causes: ($X'/M-X$)	.020

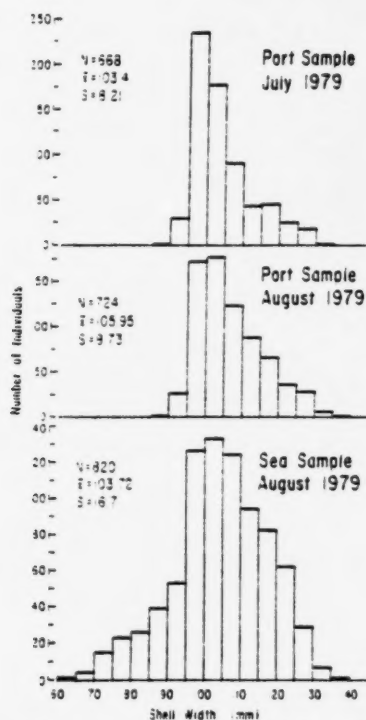


Fig. 2. Size-frequency histograms for male snow crabs for in-port and at-sea sampling from area 11, middle-eastern Cape Breton, 1979.

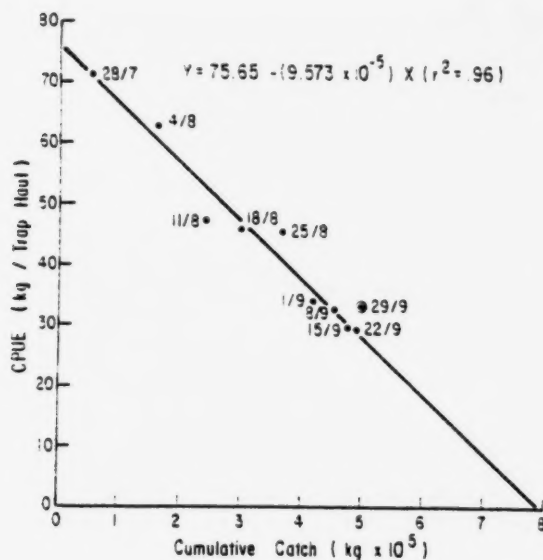


Fig. 3. Leslie graph of cumulative weekly landings of snow crabs against CPUE for area 11, middle-eastern Cape Breton in 1979.

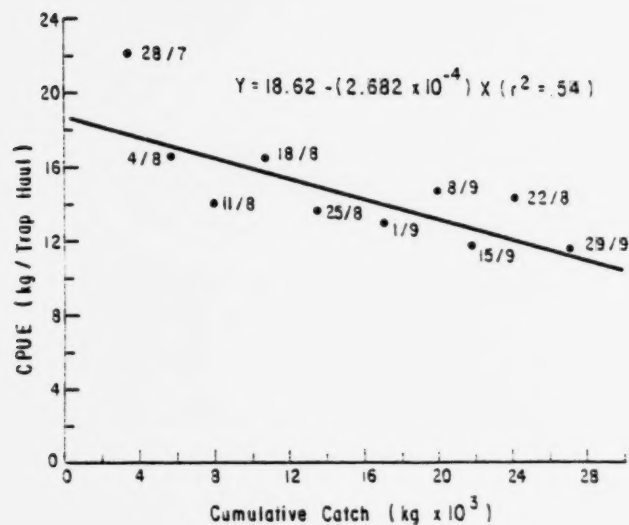


Fig. 4. Leslie graph of cumulative weekly landings of snow crabs against CPUE for area 13, southern Cape Breton in 1979.

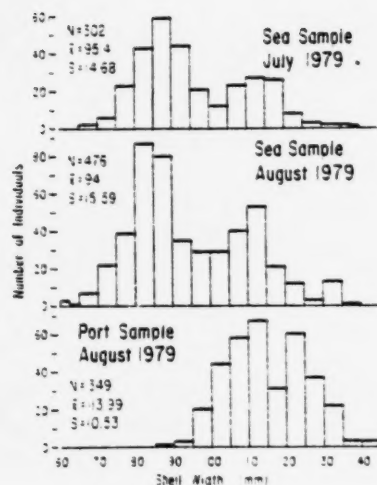


Fig. 5. Size-frequency histograms for male snow crabs for in-port and at-sea sampling from area 12, southwestern Cape Breton in 1979.

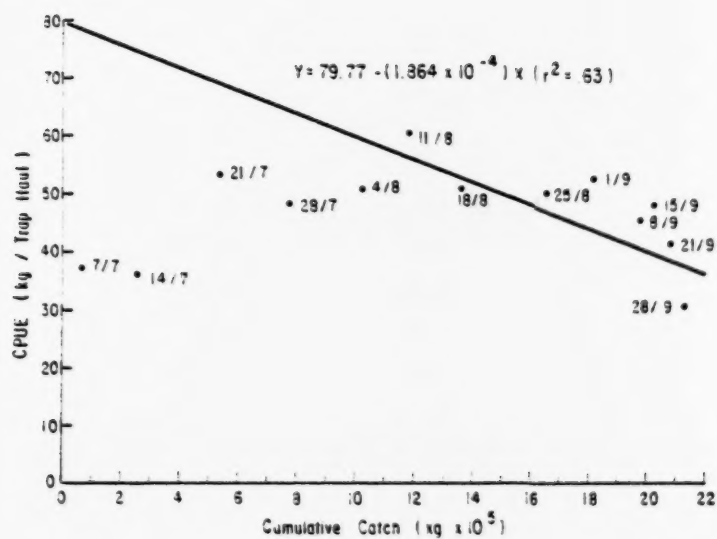


Fig. 6. Leslie graph of cumulative weekly landings of snow crabs against CPUE for area 12, southwestern Cape Breton in 1979.

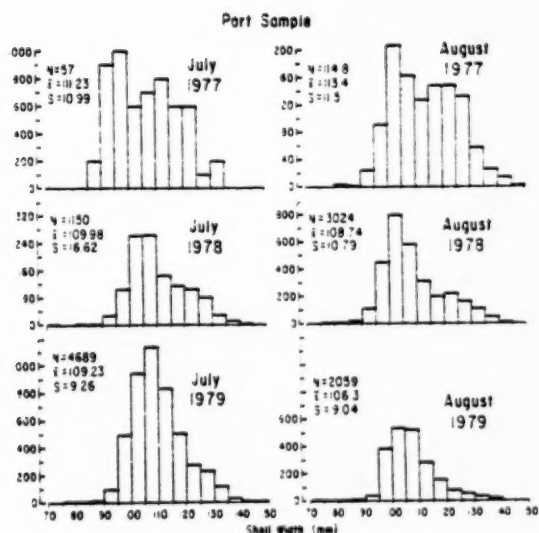


Fig. 7. Size-frequency histograms for male snow crabs from in-port samples for area 8, northwestern Cape Breton in 1977, 1978 and 1979.

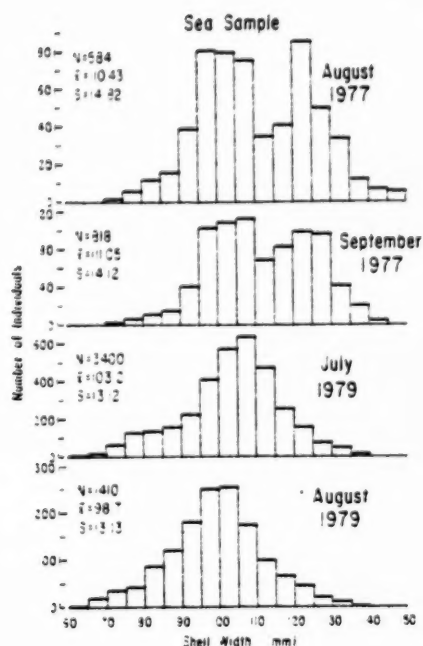


Fig. 8. Size-frequency histograms for male snow crabs in at-sea samples for area 8, northwestern Cape Breton, in 1977 and 1979.

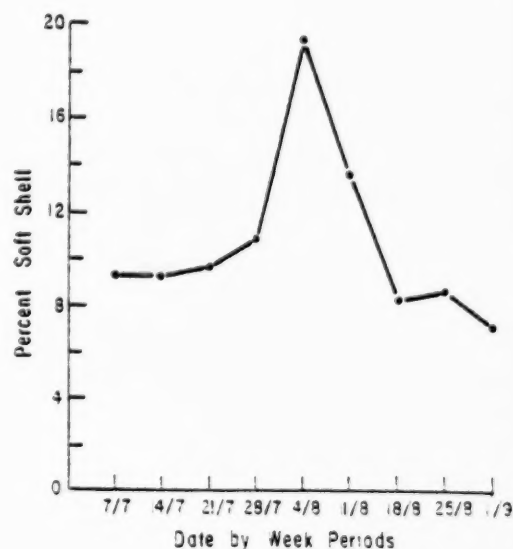


Fig. 9. Percentage frequency of occurrence soft-shelled male snow crabs in in-port samples throughout the 1979 fishing season in area 8, northwestern Cape Breton.

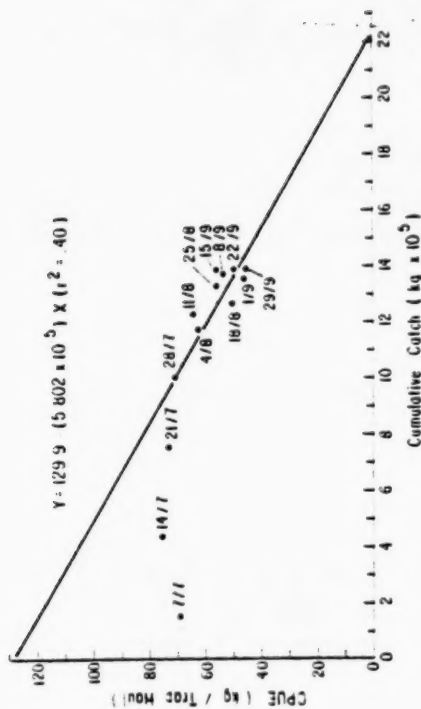


Fig. 10. Leslie graph of cumulative weekly landings of snow crabs against CPUE for area 8, northwestern Cape Breton in 1979.

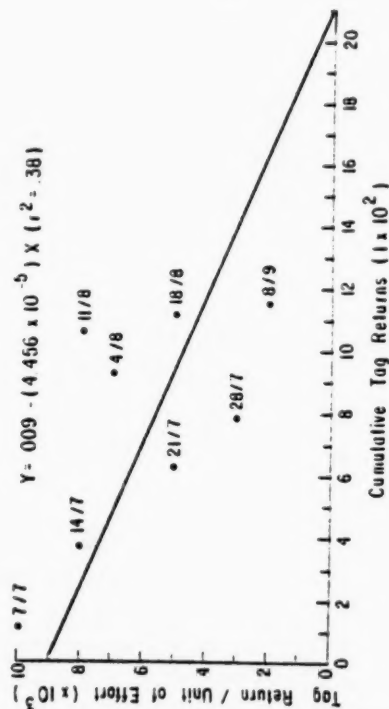


Fig. 11. Leslie graph of weekly tag returns against effort in area 8, northwestern Cape Breton in 1979.

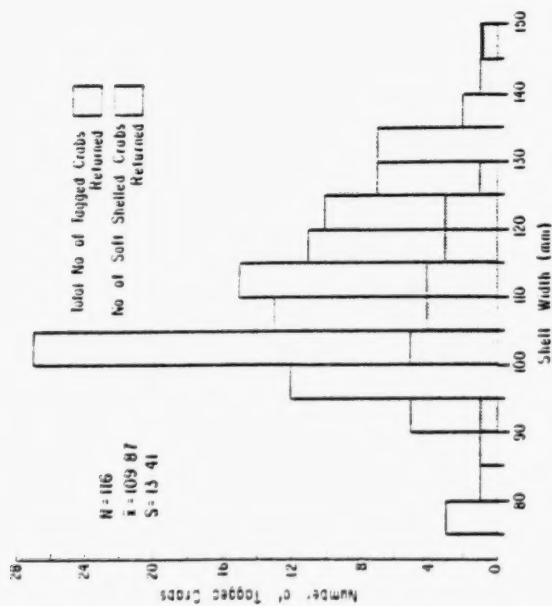


Fig. 12. Size-frequency histogram of male snow crabs (tagged in 1978) recaptured during the 1979 fishing season in area 8, northwestern Cape Breton; shell condition of crabs when originally tagged is indicated.

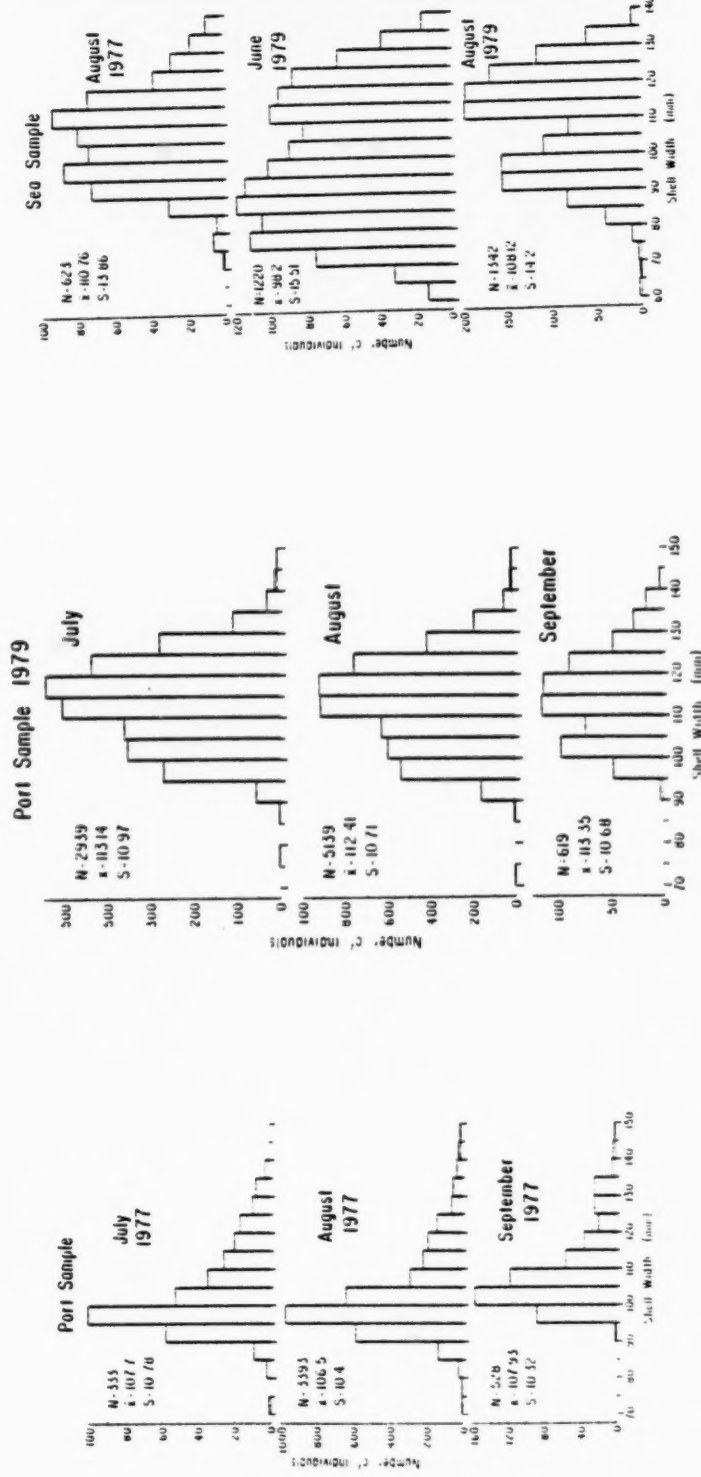


Fig. 13. Size-frequency histograms for male snow crabs from in-port samples for area 10, northeastern Cape Breton in 1977.

Fig. 14. Size-frequency histograms for male snow crabs from in-port samples for area 10, northeastern Cape Breton in 1979.

Fig. 15. Size-frequency histograms for male snow crabs from at-sea sampling in area 10, northeastern Cape Breton for 1977 and 1979.

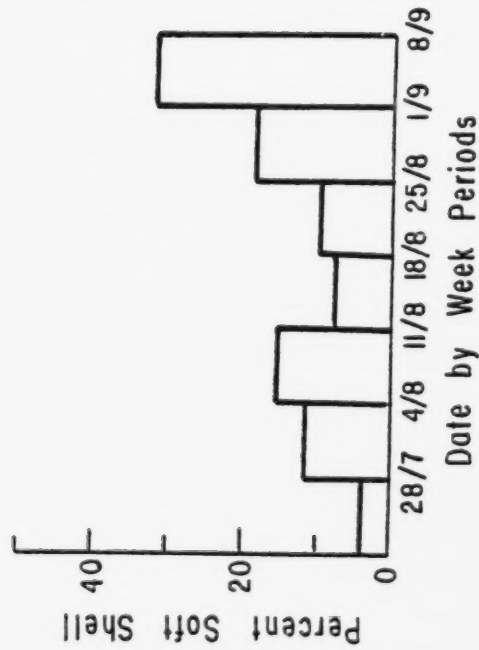


Fig. 16. Histograms of the percentage frequency of occurrence of soft-shelled male snow crabs, from in-port sampling in area 10, northeastern Cape Breton, 1979.

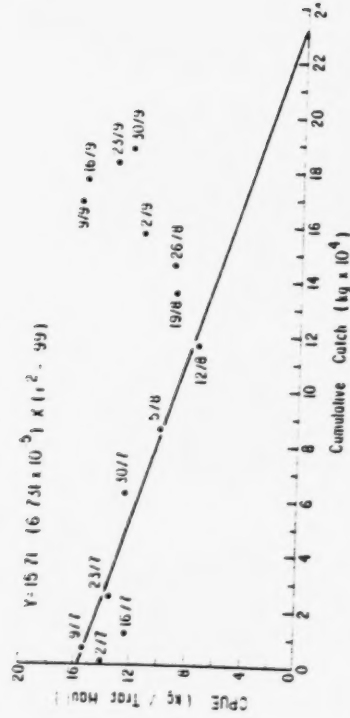


Fig. 17. Leslie graph of cumulative weekly landings of snow crabs against CPUE for area 10, northeastern Cape Breton in 1978.

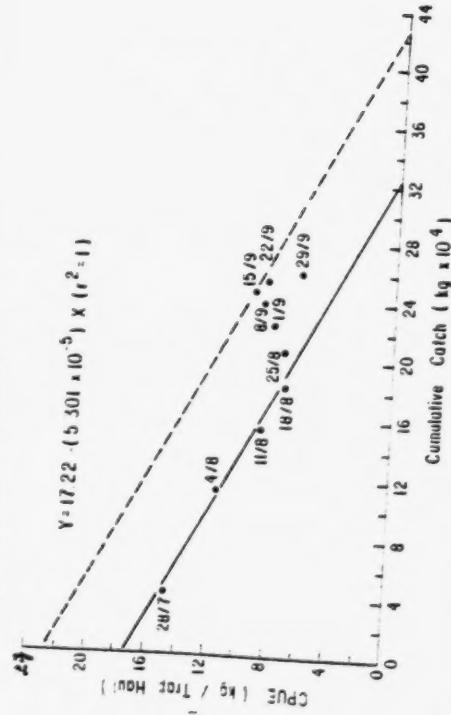


Fig. 18. Leslie graph of cumulative weekly landings of snow crabs against CPUE for area 10, northeastern Cape Breton in 1978.

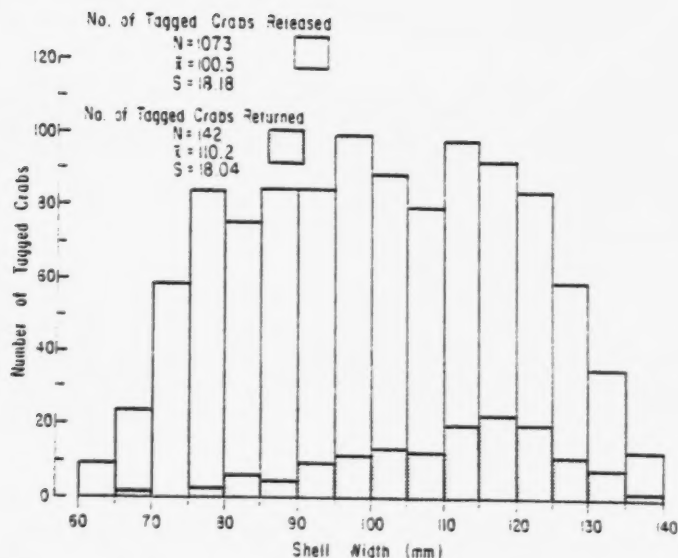


Fig. 19. Size-frequency histogram of tagged male snow crabs released and recaptured from area 10, northeastern Cape Breton in 1979.

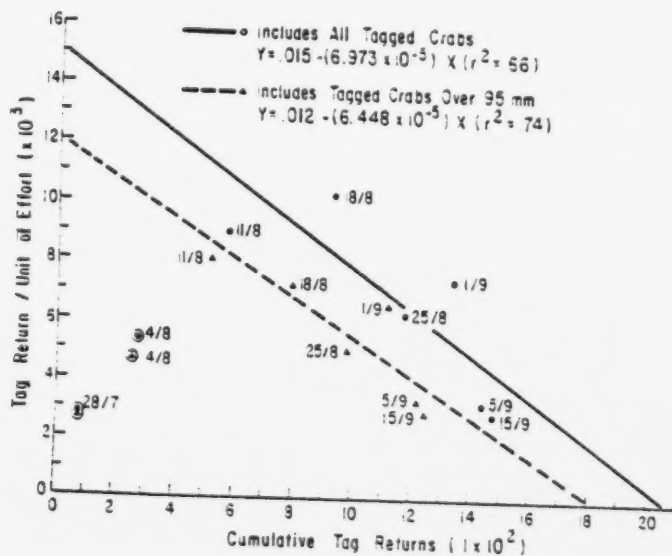


Fig. 20. Leslie graph of weekly tag returns related to effort in area 10, northeastern Cape Breton in 1979.

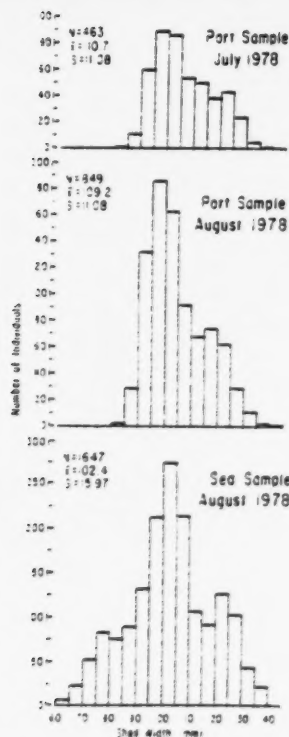


Fig. 21. Size-frequency histograms for male snow crabs in in-port and at-sea samples for area 9, southeastern Cape Breton in 1978 and 1979.

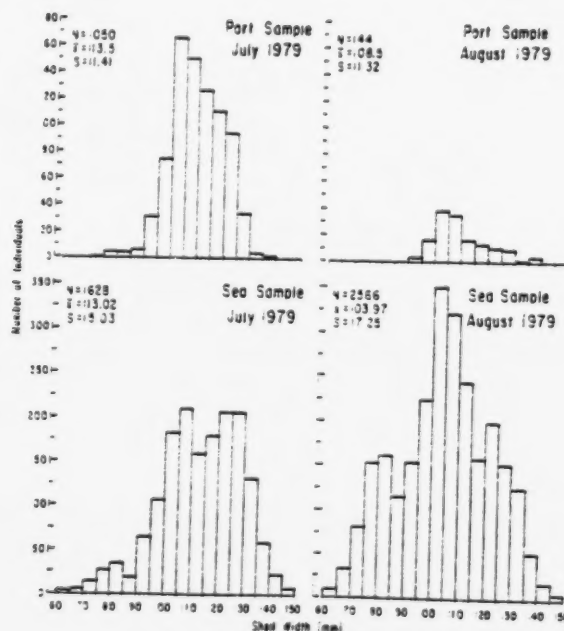


Fig. 22. Size-frequency histograms for male and snow crabs from at-sea sampling for area 9, southeastern Cape Breton in 1978 and 1979.

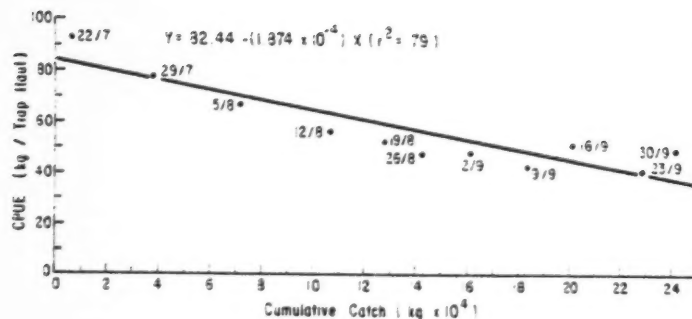


Fig. 23. Leslie graph of cumulative weekly landings of snow crabs against CPUE for area 9, southeastern Cape Breton in 1978.

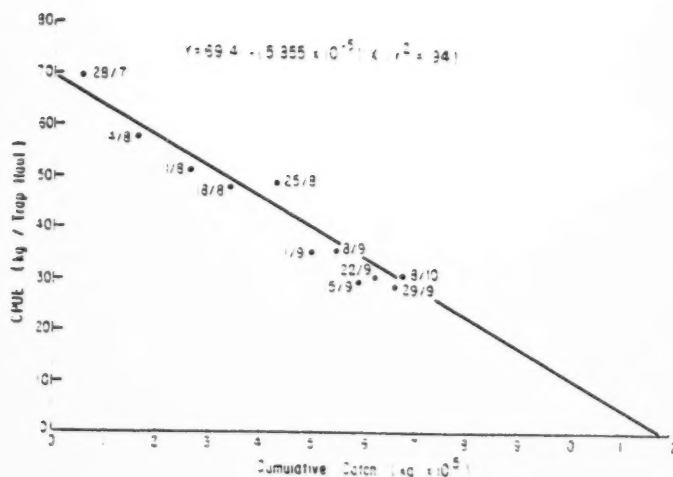


Fig. 24. Leslie graph of cumulative weekly landings of snow crabs against CPUE for area 9, southeastern Cape Breton in 1979.

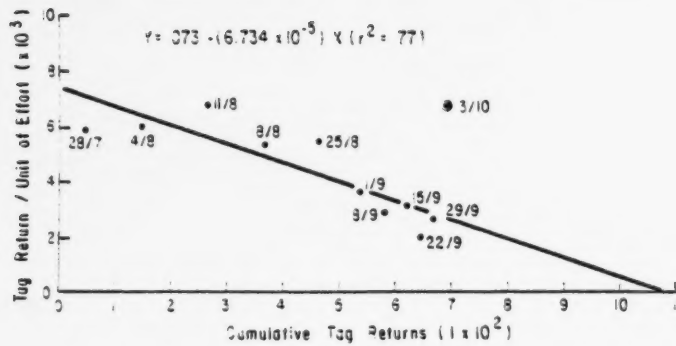


Fig. 25. Leslie graph of weekly tag returns related to effort in area 9, southeastern Cape Breton in 1979.

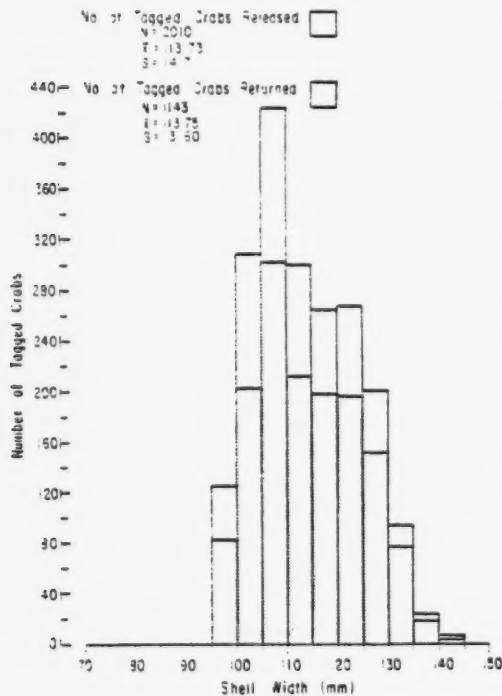


Fig. 26. Size-frequency histogram of tagged male snow crabs released and recaptured from area 9, southeastern Cape Breton in 1979.